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SPECIAL ARTICLES.

A MENDELIAN CHARACTER IN CATTLE.

CURSORY observation led me some years ago to suspect that the polled character in cattle might be a Mendelian unit character. The importance of such fact, should it prove to be a fact, may be inferred when it is remembered that every year hundreds of thousands of cattle are dehorned, while certain breeders who are trying to breed polled specimens of the ordinary horned breeds are able to dispose of polled animals at prices double those of horned animals of similar breeding. During the past summer I had the opportunity to collect sufficient data on this subject to show that the character is in all probability actually Mendelian, and have worked out rules of procedure for breeders who wish to rid their cattle of horns. The data on which my conclusions are based are presented below. Before discussing them I wish to call attention to the real meaning of the term 'Mendelian expectation,' which I fear is overlooked by some biologists, who, like myself, are only slightly familiar with the mathematics of the laws of chance.

Let us consider the case of a cross between a hybrid (*DR*) with its corresponding recessive (*R*). Suppose the cross results in 4 progeny. Ordinarily we would say that the Mendelian expectation is 2 *DR* and 2 *R*; or, in greater detail,

	Parents.	Gametes.	Conjugations.	Results.
Male	<i>DR</i>	2 <i>D</i> and 2 <i>R</i>	{ 2 <i>D</i> × <i>R</i>	2 <i>DR</i>
Female	<i>R</i>	4 <i>R</i>	} { 2 <i>R</i> × <i>R</i>	2 <i>R</i>

Here it is an even chance whether a gamete of the female parent shall be fertilized by a *D* or an *R* gamete of the male parent. The four may, therefore, be fertilized in any one of the following five ways:

	Probability of Each Case.
1. By 4 <i>D</i> gametes and 0 <i>R</i> gametes,	1
2. By 3 <i>D</i> gametes and 1 <i>R</i> gametes,	4
3. By 2 <i>D</i> gametes and 2 <i>R</i> gametes,	6
4. By 1 <i>D</i> gametes and 3 <i>R</i> gametes,	4
5. By 0 <i>D</i> gametes and 4 <i>R</i> gametes,	1
	16ths.

The probability of each of these five possible cases depends on the number of ways in which each can occur. Cases 1 and 5 can occur in only one way each; 2 and 4 can occur in four ways each; *i. e.*, the first individual may be *R* and the remaining 3 *DR*; the second may be *R* and the others *DR*, etc. The third case can occur in six ways. And so on. Altogether there are sixteen ways; hence the probabilities shown in the last column. This means that, in sixteen such cases, on the average one case will result in 4 *DR* progeny, four will result in 3 *DR* and 1 *R* progeny, etc.; and this is the real Mendelian expectation. As the combination 2 *DR* and 2 *R* would occur oftenest (six in sixteen times) we usually designate it as the Mendelian expectation, but the case 4 *DR* is also to be expected, though it will not occur so often. It would be more accurate to refer to the combination 2 *DR* and 2 *R* as the highest (but not the only) expectation. Deviations from this highest expectation are to be expected, and the number and character of such deviations can be calculated from the laws of chance.

In studying the progeny of polled Hereford bulls bred to horned cows, the very interesting fact developed that the polled character is dominant, but the hybrids frequently have imperfectly developed horns, called scurs by breeders. No case has thus far been found in which a hybrid had fully developed horns. Whether scurs always appear on the hybrids has not been ascertained. Many of the hybrids examined had no visible scurs, but many of them were calves only a few months old. Breeders state that rather large scurs occasionally develop, especially on males, on animals a year or more of age.

It was not practical to examine all the hybrids observed closely enough to determine the presence or absence of very small scurs. Questions not fully determined, and which warrant further study, are: (1) Do the hybrids always develop scurs? Final examinations should not be made before the animals are about fifteen months old. A breeder reports one case in which large scurs developed at fourteen months. (2) Do the hybrids ever

develop perfect horns? No case of this kind was observed in my studies.

The table below gives the data secured during the past season. In the column headed 'breeding,' the symbol for the male parent stands first.

PROGENY OF POLLED HEREFORD BULLS.

P = polled; *H* = horned; *Ph* = hybrid.

Breeding.	Bull.	No. of Cows.	Progeny.		Expectation.		Highest
			For <i>P</i> .	<i>H</i> .	For <i>P</i> .	<i>H</i> .	
<i>P</i> × <i>H</i>	No. 1	5	5	0	5	0	
<i>P</i> × <i>Ph</i>	" 1	6	6	0	6	0	
	" 2	56	28	28	28	28	
	" 3	39	17	22	{ 19	20 or	
	" 4	12	7	5	{ 5	4 or	
<i>Ph</i> × <i>H</i>	" 5	9	5	4	{ 4	5	
	" 6	7	2	5	{ 3	4 or	
	" 7	17	15	2	{ 9	8 or	
					{ 8	9	
					70	70	
	Omitting 6 and 7	57	59	58	58	58	
							Highest
Breeding.	Bull.	No. of Cows.	Progeny.		Expectation.		Highest
			For <i>P</i> .	<i>H</i> .	For <i>P</i> .	<i>H</i> .	
<i>Ph</i> × <i>Ph</i>	No. 5	6	5	1	5	1	
	" 6	6	2	4	4	2	
	" 7	3	3	0	{ 3	0 or	
	Totals		10	5	11	4	

From the above table it will be seen that the highest expectation is realized or very nearly so in nearly every case. Of the three cases in which the departures are considerable, in two the numbers of progeny are small (bull No. 6); in addition there is probably an error in the records in this case (see below). In the other (bull No. 7, *Ph* × *H*), the records are incomplete, and may be in error, as explained below. Omitting these two bulls from the third group, the results are very near indeed to the highest expectation.

Bull No. 1.—This animal is long since dead. The data concerning his breeding and his progeny were obtained from the records of the owner. His ancestry was such that he might have been either a pure poll or a hybrid. On the theory that he was a pure poll, and that the polled character is dominant, his progeny from both five horned and six hybrid cows (cows having one horned parent) are all polled, as they should be.

Bull No. 2.—This is a so-called 'freak,' or polled bull from horned ancestors. His numerous progeny show him to be a hybrid. Some of his near relatives were polled, and it is probable that his dam was a hybrid with large scurs. This, at least, would account for his evident hybrid character.

Bull No. 3.—This was another 'freak,' but with some polled kin. He is clearly a hybrid. His first owner bred him to five horned cows, and all the progeny had horns (or large scurs (?)). His next owner bred him to 34 cows and secured 17 polled and 17 horned calves.

Bull No. 4.—This bull was from No. 2 (hybrid) and a horned cow. He has rather large scurs, rather loosely attached to the skull, and both his breeding and his progeny show him to be a hybrid.

Bull No. 5.—Out of a horned cow and by a polled bull, hence a hybrid. His progeny in both the third and fourth groups meet the highest Mendelian expectation.

Bull No. 6.—This is another 'freak,' a registered Hereford. He has small scurs. How he came by his apparent hybrid character is unknown. It will be noticed that when bred either to horned or hybrid cows his horned progeny are in excess of the highest expectation. This is probably an error. His owner, for fear of misrepresenting facts to purchasers, states that he has always counted large scurs as horns, and they so appear in his records. Although the number of progeny is small, and might, therefore, depart widely from expectation without vitiating the results, it is probable that a careful examination of his progeny, which I was unable to make except in a few cases, would show that the actual numbers agree more closely with expectation than those shown.

Bull No. 7.—In this case the departure is very large, in the case of progeny from horned cows. By his breeding he must have been a hybrid, unless his owner erred in recording the dam as horned when she was really a hybrid with large scurs. Both sire and dam are dead, and this point can not now be determined. It is possible, however, that this error was made, as the owner is the breeder

who, as above stated, recorded large scurs as horns. If the dam was really a hybrid, as I suspect, and the two horned calves in the third group had large scurs instead of horns, the results would agree exactly with the admissible theory that he was a pure poll. On the other hand, no record was made of a number of his get from common cows, so that, on the theory that he was a hybrid, the missing horned calves in group 3 may be the progeny of these unrecorded common cows.

From the above it will be seen that the only results not agreeing closely with theory are doubtful, while in every case where no doubt exists the results are in very satisfactory agreement with theory. These facts render it highly probable that the polled character is a dominant Mendelian unit character.

Dehorning a Breed of Cattle.—Assuming the above conclusion to be true, the dehorning of a breed of cattle is fairly simple. A single hybrid animal would suffice for this purpose, though this would require some inbreeding. It would be better perhaps for several breeders to cooperate, so as to avoid the necessity of inbreeding. An occasional polled animal occurs in all breeds of cattle, and these can be used in such a manner as to produce a new polled breed. In some instances polled animals of other breeds have furnished the starting point, it being possible to transfer the single character desired from one breed to another.

Suppose several breeders secure polled bulls (either pure polls or hybrids) to head their herds. These are bred to large numbers of horned cows. The get of the pure polls will all be polled hybrids, and half the get of the hybrids, in this case, will be polled hybrids. Now, by breeding these polled hybrids together we get one fourth pure polls, one half hybrid polls and one fourth horned. The pure polls thus obtained may become the basis of the future polled herds. The pure polls can be distinguished from the hybrids as follows: In the first place some (may be all) the hybrids will have scurs. In the second place, we may distinguish them by their progeny. Breed the animal to several horned animals; if the progeny are all polled, the polled parent is a

pure poll; if half the progeny are horned, the polled parent is a hybrid.

In the case of males, if we breed to twelve horned cows and secure twelve polled calves, the chances that the male is pure and not a hybrid are 4,096 to 1. (Twelfth power of $2 = 4,096$.) If any of the twelve progeny develop perfect horns the chances are great that the bull is a hybrid.

It is more difficult to determine whether a polled cow is pure or hybrid. If she have scurs, even very small ones, she is hybrid. If not, so far as we now know, she may be either pure or hybrid. If she regularly produces polled calves from horned sires she is pure. But, when breeding for polled animals, it is expensive to test a polled cow in this way. The better plan is to be sure as to the males in all cases and treat all females as pure polls unless they have scurs or horns. In time the horns will disappear from the breed. It is highly important to remember that when a horned calf occurs in a polled breed, either it is a hybrid with horns, a thing not yet certainly known, or *both* of its parents are hybrids. There are undoubtedly a few such hybrids in all polled breeds, and when two such hybrids mate, one fourth of the progeny is horned. The number of such hybrids in a breed may be rapidly reduced by discarding both sire and dam of all horned animals that occur. The same thing will be accomplished less rapidly by discarding only the sires. The occurrence of scurs, but not perfect horns, in an established polled breed indicates that one parent only is hybrid.

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PRELIMINARY NOTES ON THE ARCHEOLOGY OF THE YAKIMA VALLEY, WASHINGTON.¹

Archeological explorations² were made in the Yakima Valley, Washington, for the American Museum of Natural History in the

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² The first report of these explorations appeared in *The American Museum Journal*, pp. 12-14, Vol. IV., No. 1, January, 1904. It was slightly revised and appeared in *SCIENCE*, N. S., pp. 579-